International Journal of Agricultural
Science and Research (IJASR)
ISSN(P): 2250-0057; ISSN(E): 2321-0087
Vol. 7, Issue 2, Apr 2017, 49-54

BIOCONVERSION OF AGRO - LIGNOCELLULOSIC WASTE INTO PROTEINACEOUS MASS – A POSITIVE APPROACH (REVIEW)

AAGOSH VERMA & ANURADHA SINGH

Department of Zoology, Environmental Molecular Biology Laboratory, University of Rajasthan, Jaipur, India

ABSTRACT

India is mainly an agricultural country. This fact has been corroborated by the World Bank data, which reveals that India uses 60.3% of its land for agricultural purposes. In addition, the occupation of more than 50% of the citizens depends directly on the various aspects of farming. The agricultural sector generates a major portion of the waste, which is by and large biodegradable. The agro-industries, such as the food processing units, cotton mills, sugar mills, paper mills, textile factories and slaughterhouses (the sewage waste from such units), are the main contributors to the waste production. The biodegradable waste generated is basically lignocellulosic in nature. Generally, these wastes are disposed in the land or are burned. In either manner, it causes pollution (land or air). However, because agricultural waste is natural organic compounds, steps may be undertaken to degrade these products before their release into the environment. Biological degradation, with the help of microbes, is the method of choice. This review deliberates on the breakdown of the lignocellulosic waste with the help of edible mushrooms. This bioremediation method not only produces a proteinaceous food for the masses, but also is responsible for generating employment to many. Furthermore, this technique boosts the usage of mycoremediation technology for pollution control.

KEYWORDS: Lignocellulose, Mushroom & Agricultural Waste

Received: Jan 08, 2017; **Accepted:** Feb 07, 2017; **Published:** Feb 17, 2017; **Paper Id.:** IJASRAPR20177

Review Article

INTRODUCTION

Worldwide, in today's scenario, pollution is the main culprit for most of the problems facing the human population. In this review, we are mainly involved in the disposal of lignocellulosic waste produced by the agriculture sector. Several studies have been undertaken to convert the waste into a useful product by treatment and conversion. In addition, steps to reduce the waste production need to be taken. Mycoremediation may prove to be as one successful method. This method employs fungi to fix the pollution issues. These organisms have a versatile nature and are well-known for their capability to degrade solid waste (Rhodes, 2012). Fungi play an important role as degraders in the soil food web.

In point of fact, only fungi can decompose wood. They do so by the vigorous action of the extracellular enzymes and acids, which can degrade the main elements of plant cells (lignin and cellulose). In doing so, the fungal mycelia replenish the soil with nutrients, such as nitrogen, phosphorus, potassium, and other essential inorganic nutrients (Rhodes, 2013). The use of mushrooms (macrofungi) for treatment of lignocellulosic waste is an illustration on mycoremediation.

Mushrooms are employed for bioremediation because of their role in biodegradation, biosorption and bioconversion (Akinyele et al. [2012], Kulshreshtha et al. [2013a]; Kumhomkul and Panich-pat [2013]; Lamrood and Ralegankar [2013]). Different enzymes have been researched for this purpose (Novotný et al. [2004];

Akinyele et al. [2011]; Zhu et al. [2013]), but the ones produced by mushrooms have proven to be the most successful. Pleurotus species of mushroom are one of the popular choices, because of its easy cultivation, adaptation to varied temperature range, and its ability to grow on various substrates, even lignocelluloses (Gogoi and Adhikary, 2002). Furthermore, because these mushrooms are adapted o varied temperatures, their cultivation in the tropical climates of India does not pose a challenge.

Globally, the production of Pleurotus sp. has reached on par with Agaricusbisporus (Lange) Syng. Mushrooms are known to be employed to tackle the degradation of not only lignocelluloses but also various industrial wastes (Singhal et al. [2005]; Dulay et al. [2012] and Aagosh et al 2013). The usage of mushrooms is multibeneficial. It produces protein-rich carpophores (a major vegetarian source of proteins), resolves pollution problems by the direct disposal of lignocellulosic waste, and upholds the usage of mycoremediation for sustainable pollution control.

The Pleurotus mushrooms are known for their medicinal properties. They have a characteristic taste and aroma. They have abundant protein and carbohydrate content, fiber, vitamins and minerals. Antibacterial properties, as well as hypochlosterolemic and immunomodulation activities (Patel et al., 2012), has been reported by these species. In addition, their benefits have been availed in biotechnological and environmental techniques, such as bioconversion of agriculture waste, as animal feed, and biodegradation of organic and industrial pollutants.

Pleurotus sajor-caju (grey oyster mushroom) is more suited for the tropical and subtropical climates, as they are best suited to high temperatures among all the species of Pleurotus. In addition, their cultivation is simple, without the use of any complicated procedures (Chang and Miles, 2004, Kaul and Dhar, 2007).

Prerequisites for cultivation: The mycelium are grown at 10-35^{o}C, with the optimum temperature range of 23-28^{o}C, While fruiting, temperature is set at 18-24^{o}C. The substrate bag/bedis maintained at an optimum pH of 6.8-8.0. The carbon-to-nitrogen ratio in the substrate is 30:60. Proper circulation of air is maintained and adequate light provided to ensure the development of the mushrooms.

Table 1: Some of the Recent Studies that have Considered Pleurotus Usage for Degradation of Agriculture Waste are Listed in the Table Below

No.	Substrate	Reference
1	Composted saw dust	M. Obodai et al., 2002
2	Wheat straw, soybean straw, and groundnut shells	Mane et al., 2007
3	Wheat straw	Mandhre et al., 2008
4	Domestic waste (vegetable biomass from bitter gourd, chilly, cow pea, French bean, and potato)	Ganeshan et al., 1989
5	Waste paper	Baysal and Parker., 2003
6	Newspaper and used tea leaves	Jain., 2005
7	Paddy straw with combination of oil seed rape	Ahma et al., 2008
8	Lignocellulosic substrates: conventional viz. wheat straw (WS), paddy straw (PS), and soybean straw (SS); and non-conventional substrates viz. domestic wastes (DW), used tea leaves (UTL), and newspaper waste (NPW) supplemented with soybean bran and groundnut bran	
9	Maize stalk, pea residue and banana leaves	Chandra P. Pokhrel et al., 2013
10	Paddy straw, Wheat straw, Apple leaves, and Chinar leaves	Shauket et al., 2012
11	Corn cob substrate	Stanley et al., 2011
12	Oil mill waste	Alejandro et al., 2010

Table 1: Contd.,		
13	Leaves and bark of common fruit trees	F C Adesina et al., 2011
14	Wheat straw, paddy straw, soybean straw, pigeon pea straw and green gram straw	Survase D. M., 2012
15	Cotton waste	Tan 1981
16	Cereal bran	Kinugawa 1994
17	Coffee pulp	Martinez-C arrera (1989); Sanchez et al.,(2002); Upadhyay and Sohi (1988)
18	Corncobs	Heltay (1957); Heltay et al., (1960); Naraian et al, (2009, 2014)

The aforementioned studies have mainly employed forest and agricultural products as the substrate. This study proposes to use lignocellulosic waste. Any lignocellulose material may be used as a substrate, based on its availability, abundance, and cost (Oso 1977a), for the study.

A concise account on the benefits of mushroom cultivation are enumerated as follows:

Pollution Control and Mushroom Cultivation

Organic solid waste is produced in large quantities on a daily basis. Agriculture based lignocellulosic waste are a major contributor to it. Lignocelluloses comprise cellulose, hemicellulose, and lignin. These wastes are not utilized by any other industry and are therefore dumped into the environment, where they contribute to the pollution of land, air, and water resources. Mushrooms may provide a solution to this problem, because their hydrolytic and oxidative enzymes have been reported to effectively degrade the lignocelluloses, while simultaneously absorbing them as nutrition. Furthermore, the degraded lignocellulose post cultivation may be employed as compost. This compost is rich in nitrogenous elements, and so may be combined with animal dung or human excreta biogas production. The sludge from the biogas plant is a more efficient biofertilizer. If the biogas is generated in the vicinity of the mushroom house, then it can be used to generate electricity for the pasteurization of the mushroom bed substrate and to maintain optimal cultivation temperatures.

For the rural population, integrated approach to mushroom cultivation, with biofertilizer and biogas production, may have more relevance. This practical approach would generate income in the rural areas, and at the same time help in the successful utilization and disposal of the rural and urban lignocellulosic waste. This concept of multiple end products and complete breakdown of the product is termed as "Zero Emission or Total Productivity."As it is said, "The earth can not produce more: Man has to do more with what the earth produces" (Pauli, 1996; Chang, 2007), sustainable usage of products complemented with recycling and re-usage is the need of the hour.

Mushroom cultivation may help to generate additional income in the rural sector, especially by the women and the unemployed youth. This secondary income may help to improve their social status. In addition, mushroom cultivation may be successfully done in the winter months and the dry seasons when farming may not be in full-fledged.

Mushrooms serve as a supplementary protein-rich food to the masses. They have significant levels of the essential minerals and vitamins, which have a direct impact on human health. Several bioactive compounds are extracted from medicinal mushrooms and supplied as capsule to improve immunity and the quality of life in humans.

Mycorestoration of the environment: Saprotrophic, endophytic, mycorrhizal, or even parasitic fungi/mushrooms have been reported to restore damaged environments. They may do so by the following varied formats: mycofiltration—fungal mycelia are used as water microfilters; mycoforestry—mycelia restore forests by increasing the organic content, making nutrients available, increasing the retention of water by the soil; mycoremediation—mycelia eliminate toxic waste by degrading them into simpler non-toxic forms; mycopesticides—employingcertain exotoxin-producing mycelia to eliminate pests. These methodologies restore the ecosystem without any further damage (Stamets 2005).

CONCLUSIONS

Cultivation of mushrooms supplement food sources and may help to eliminate the shortage of protein-rich food. In addition, they are a good source of nutrients for improvement of human health. Furthermore, mushrooms may help in tackling some of the pollution issues facing humankind. Mushroom biology links food production with sustainable development.

Governments, research centers, and educational institutions play a key role in gathering attention on these important features of mushrooms. They can promote the commercialization of mushroom technology, as well as create awareness for the same. They also need to ensure that all research on this aspect in the laboratory is applied to the fields. Campaigns need to be done so that the farmers may avails of these benefits in technology. Oyster mushrooms can be commercially produced in a cost-effective manner if the substrate used is widely available and cheap. The use of agro waste is, therefore, a very efficient concept. This has been proved both economically and ecologically. However, the availability of suitable substrates varies geographically. Therefore, the farmers need to be trained and provided technical awareness about the various substrates that may be employed in mushroom cultivation. In addition, they need to be taught about the optimization procedures for the various substrates. The endorsement of mushroom cultivation not only helps in generating employment, but also the mushrooms are a source of nutrition. It is a source of revenue for the landless poor and the economically weaker sections of society.

REFERENCES

1. *Rhodes, C. J. (2012) Feeding and healing the world: through regenerative agriculture and permaculture. Sci. Prog., 95(4):345-446.*
2. *Rhodes, C. J. (2013) Applications of bioremediation and phytoremediation. Sci. Prog., 96(4): 417-427.*
3. *Akinyele, J B, Fakoya, S, Adetuyi, C F (2012) Anti-growth factors associated with Pleurotus ostreatus in a submerged liquid fermentation. Malaysian J Microbiol 8: 135–140.*
4. *Kulshreshtha, S, Mathur, N, Bhatnagar, P (2013) Mycoremediation of paper, pulp and cardboard industrial wastes and pollutants. In Fungi as Bioremediators: Soil Biology. Edited by: Goltapeh EM, Danesh YR, Varma A. Springer Berlin, Heidelberg; 2013:77–116*
5. *Kumhomkul, T, Panich-pat, T (2013). Lead accumulation in the straw mushroom, Volvariellavolvacea, from lead contaminated rice straw and stubble. Bull Environ ContamToxicol., 91: 231–234*
6. *Lamrood, P Y, Ralegankar, S D (2013) Biosorption of Cu, Zn, Fe, Cd, Pb and Ni by non-treated biomass of some edible mushrooms. Asian J ExpBiol Sci.,4: 190–195*

7. *Novotný, C, Svobodová, K, Erbanová, P, Cajthaml, T, Kasinath, A, Lang, E, Šašeka, V. (2004) Ligninolytic fungi in bioremediation: extracellular enzyme production and degradation rate. Soil BiolBiochem., 36: 1545–1551.*
8. *Akinyele, B J, Olaniyi, O O, Arotupin, D J (2011) Bioconversion of selected agricultural wastes and associated enzymes by Volvariellavolvacea: An edible mushroom. Res J Microbiol., 6: 63–70.*
9. *Zhu, M J, Du, F, Zhang, G Q, Wang, H X, Ng, T B (2013) Purification a laccase exhibiting dye decolorizing ability from an edible mushroom Russulavirescens. IntBiodeteriorBiodegrad., 82: 33–39.*
10. *Gogoi, G. and Adhikary, A. K. (2002) Suitability of certain newer plant waste for production of oyster mushroom. Mushroom Res. II: 25-27*
11. *Kaul, T. N. and Dhar, B. L. (2007) Biology and Cultivation of Edible Mushrooms. New Delhi: Westville Publishing House, p. 240*
12. *Mane, V P, Patil, S S, Syed, A S, Baig, M M V, (2007) Bioconversion of low quality lignocellulosic agricultural waste into edible protein by Pleurotus sajor -caju(Fr.) Singer. J. ZhejiangUniv.B., 8: 745-751.*
13. *Chandra, P. Pokhrel, Neelam Kalyan, Usha, Budathoki and Ram Kailash P. Yadav. (2013). Cultivation of Pleurotus sajor-caju using different agricultural residues. International Journal of Agricultural Policy and Research, 1(2):19-23.*
14. *Shauket, A P., Abdul, H W. And Riyaz, A M. (2012) Yield performance of Pleurotus sajor- caju on different agro-based wastes. Annals of Biological Research, 3 (4):1938-1941.*
15. *Survase, D. M. (2012) Bioconversion of agro waste into edible protein rich mushroom by pleurotussajor-caju (Fr.) singer. Trends in biotechnological research. www.sciencejournal.in*
16. *Adesina, F C., Fasidi, I O, Adenipekun, O C. (2011). Cultivation and fruit body production of Lentinussquarrosulus Mont. (Singer) on bark and leaves of fruit trees supplemented with agricultural waste. Afr. J. Biotechnol. 10(22):4608-4611.*
17. *Martinez - Carrera, D. (1989) Past and future of edible mushroom cultivation in tropical America. Mush Sci. 12(1): 795 – 805.*
18. *Kinugawa, K., W. Phusawang, S. Chinbenjaphol, S. Fukada, E. Tanesaka, M. Okada, and H. Tsutsui. (1994) Progress Report (1991-1993) of joint research program of Kinki and Chiang Mai Universities on the promotion of mushroom research. MemFacAgr Kinki Univ., 27:93-113*
19. *Oso, B. A. (1977a) Pleurotus tuber-regium from Nigeria. Mycologia, 69:271-279*
20. *Naraian, R., Sahu, R. K., Kumar, S., Garg, S. K., Singh, C. S., Kanaujia, R. S. (2009) Influence of different nitrogen rich supplements during cultivation of Pl Eurotusflorida on corn cob substrate. Environmentalist, 29:1-7.*
21. *Naraian, R., Narayan, O. P., Srivastava, J. (2014) Differential response of oyster shell powder on enzyme profile and nutritional value of oyster mushroom Pleurotus Florida PF05.BioMed. Res. Int., Article ID 386265, http://dx.doi.org/10.1155/2014/386265*
22. *Singhal, V., Kumar, A., Rai, J P., (2005) Bioremediation of pulp and paper mill effluent with Phanerochaetechrysosporium. J Environ Biol.,* ***26:*** *525–529.*
23. *Dulay, R M R., Parungao, A G., Kalaw, S P., Reyes, R G. (2012) Aseptic cultivation of Coprinuscomatus (O. F. Mull.) Gray on various pulp and paper wastes. Mycosphere., 3: 392–397.*
24. *Jain, A. K. and Vyas, D. (2005) Comparative study on the yield of three Pleurotus sp. grown in several lignocelluloses By-products. J. Basic Appl. Mycol., 4:155-157*

25. Patel, Y., Naraian, R., Singh, V. K. (2012) Medicinal properties of Pleurotus species (Oyster mushroom): A review. World J. Fungal Plant Biol.,3(1): 01-12

26. Heltay, I., (1957). Report of the situation of Hungarian mushroom research and experimental work. Mush Sci., 3:199-217.

27. Heltay, I., I. Zavodi. (1960) Rice straw compost. Mush Sci., 4:393-399.

28. Sanchez, A., Ysunza, F., Beltran- Garcia, M. J., Esqueda, M., (2002) Biodegradation of viticulture wastes by Pleurotus: a source of microbial and human food and its potential use in animal feeding. J.Agric. Food Chem., 50(9): 2537-42.

29. Upadhyay, B., Sohi, H. S. (1988) Apple pomace, a good substrate for the cultivation of edible mushrooms. Curr.Sci., 57: 1189-1190.

30. Stamets, P. (2005) Mycelium Running: How Mushrooms Can Help Save the World. Berkley: Ten Speed Press

31. Pauli, G. (1996) Breakthroughs: What Business Can Offer Society. Surrey: Epsilon, p. 243.

32. Chang, S. T. (2007) Mushroom cultivation using the "ZERI" principle: potential for application in Brazil. Micol. Apl. Int., 19:33-34.

33. Chang S. T. and Miles, P. G. (2004) Mushrooms: Cultivation, Nutritional Value, Medicinal Effect, and Environmental Impact (Second Edition), 451 pp. Boca Raton, Fl: CRC Press.

34. Tan K. K. (1981) Cotton waste is a fungus (Pleurotus) good substrate for cultivation of Pleurotus ostreatus the oyster mushroom. Mush. Sci., 11:705–710.

35. Alejandro R R., Cristina, S R., Isabel, P., Harry, J W. (2010) Effect of olive mill waste (OMW) supplementation to Oyster mushrooms substrates on the cultivation parameters and fruiting bodies quality, International Biodeterioration& Biodegradation, 64(7): 638–645.

36. Ahma, D. N., Gholamali, P. and Jamalali, O. (2008) Oilseed Rape straw for cultivation of oyster mushroom. Nature Preceding, 1-13.

37. Verma, A., Singh, A., Mathur, N., Atri, R., Sharma, S. (2014) Bioremediation of dairy Industrial sludge through cultivation of mushrooms, International Journal of Advanced Biotechnology and Research, 5(2): 169-179.

38. Ganeshan, G., Tewari, R. and Bhargava, B. (1989) Influence of residual vegetable crop on yield and mineral content of Pleurotus sajor -caju. Mushroom Science, 12(2): 91-97.

39. Baysal, E., Parker, H., Yalinkilic, M. K. and Temiz, A. (2003) Cultivation of oyster mushroom on waste paper with some added supplementary materials, Bioresource Technology, 9: 95-97.

40. Mandhare, V. K., Suryawanshi, A. V. and Mate, S. N. (2008) Productivity and nutritive value of Pleurotus spp. On wheat straw and its effects on nutritional indices of spent straw. Agricultural Science Digest, 28:19.

41. Stanley H. O. (2011) Cultivation of oyster mushroom (Pleurotus pulmonarius) on amended corncob substrate Agric. Biol. J. N., 2(10): 1336-1339.

42. Chang, S. T. (2007) Mushroom cultivation using the "ZERI" principle: potential for application in Brazil. Micol. Apl. Int., 19:33-34.